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PATENT SPECIFICATION

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COMPLETE SPECIFICATION

DRAWINGS ATTACHED

Improvements in and relating to Films of Thermoplastic Material

We, T. J. SMITH & NEPHEW LIMITED, a British Company, of Neptune Street, Hull, Yorkshire, do hereby declare the invention for which we pray that a patent may be granted to us and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to thin films of any suitable thermoplastic material which is capable of being softened and melted by heat, and more particularly to a method and means for imparting to such films a desired pattern of perforations, even very fine perforations, which extend through the thickness of the film; and also to the perforated films so produced.

The Specification of British Patent No. 851473 discloses a method of perforating a sheet of flexible thermoplastic organic polymeric sheet material, which comprises melting and perforating the material of the sheet at selected localised areas thereof, by subjecting the sheet to the action of hot fluid whilst simultaneously cooling other areas of the sheet to prevent those other areas from melting.

The said cooling of these other areas may be effected by cooling the side of the sheet remote from that exposed to the hot fluid, and in one practical method the sheet is moved relatively to a stream of hot fluid whilst in contact with a cooled perforated supporting surface, so that the hot fluid produces the perforations in the uncooled portions of the sheet in register with the perforations in the cooled supporting surface. These perforations in the sheet may be minute and only minutely separated from one another, whilst apparatus for carrying out the above practical method comprises a perforated heat-

conductive surface for supporting the sheet to be treated, means for cooling the supporting surface, means for directing a stream of hot fluid, which can have a temperature of 875°C, on to the exposed surface of the sheet on the supporting surface, and means for providing relative motion between the supporting surface and the stream of hot fluid in a direction transverse to the direction of the stream, the supporting surface in particular cases being the outer surface of the perforated peripheral wall of a rotatable hollow cylinder, and the apparatus including a reel from which the sheet is fed continuously around part of the circumference of the said hollow cylinder, to a take-up roll.

According to the present invention, a method for imparting to a film of any suitable thermoplastic material which is capable of being softened and melted by heat, a pattern of perforations which may be fine perforations and which extend through the thickness of the film, which thickness is within the range of approximately 0.00025" to 0.005", comprises holding the film slightly stretched over and in contact with a segment of a cylindrically curved metal surface, said curved surface having a pattern of air-containing indentations thereon of very slight depth, which may range from a few thousandths of an inch upwards, and whilst so held and without moving the film in relation to the curved metal surface, subjecting the outer surface of the thus held thin film to the heat at the tip of a flame which has a temperature of 1200°C or more and is directed onto the surface of the film for only a small fraction of a second, which is insufficient to melt the material of the film where it is in contact with the metal owing

[Price

to the high heat conductivity of the metal, but long enough to melt the said material where it is located over the indentations owing to the relatively low heat conductivity of the air in the indentations and the expansion of the air held in the indentations, by the heat, the flame heating action being effected by moving the said flame or simultaneously moving a plurality of said flames in relation to the outer surface of the film so that all parts of the whole area to be perforated are subjected to the very short period of treatment, to produce a pattern of perforations through the material which corresponds to that of the indentations on the metal surface.

The material of the film which comes under the action of the flame and which is located over the very shallow indentations in this zone, will melt by this treatment provided that the various governing features are correctly chosen, and by the relative movement of the flame in relation to the film and curved metal surface, the pattern of perforations through the film will conform generally to that of the indentations, although if the indentations are circular their diameter may differ, for example be somewhat less.

The desired temperature and time period can readily be found experimentally for any given material, thickness of material, and pattern of shallow indentations, as well as the particular combustible gas mixture for the flame. Experimentally, Town gas and air has been used, and also an oxyacetylene mixture, and both of these have given successful results.

A practical apparatus for providing perforated thin films according to the invention could comprise a rotatable hollow metal cylinder with the indentations on its outer surface, as a carrier for the film, which film is held under slight tension in contact with a desired segment of the surface. The film proceeds from a let-off roller and passes to a take-up roller via the said carrier, and while the film is in contact with the indented curved surface of the rotating cylinder it does not move over the said surface, but with the said surface.

In an intermediate position of this contacting portion of the film with the curved surface of the cylinder, the outer surface of the slightly stretched film passes in front of a row of flames which form the heating means, and the spacing of the burner for the flames, from the surface of the film, may be adjustable.

In operation, the film and hollow cylinder turn as one for that portion of a revolution in which the film contacts the indented surface of the cylinder, and in an intermediate position of this portion the flaming treatment is applied. To prevent the cylinder from being over heated, cooling means such as a

circulating liquid coolant may be applied to the interior thereof. This prevents the film sticking to the cylinder and maintains the metal of the cylinder and the air in the indentations at the same cold temperature. This applies particularly to the air held in the indentations by the film portion lying in contact with the surface of the cylinder which is approaching the flaming position.

With continuous operation there could thus be produced a perforated film of a standard width having approximately a thousand, or even more, uniformly spaced fine perforations per square inch. However, it must be realised that these particulars are not limitative as other spacings may be as readily produced.

In order that the invention may be better understood, it will now be described with reference to the accompanying diagrammatic drawings which are given by way of example only and in which:—

Fig. 1 is a diagrammatic cross-sectional elevation of one method of carrying the invention into effect.

Fig. 2 is a plan of a portion of Fig. 1.

Fig. 3 is a fragmentary perspective view of a portion of the burner.

Fig. 4 is a fragmentary sectional elevation through the burner.

Fig. 5 is a sectional elevation to a highly magnified size, of a portion of film under treatment, to illustrate the action, and

Fig. 6 is a greatly enlarged view of a flat portion of a film having perforations made therethrough in accordance with the invention.

In the diagrammatic drawings, 7 is a hollow metal cylinder with closed ends, having hollow stub spindles 8 in communication with the interior, mounted in bearings 9 and adapted to be rotated in the direction of the arrow 10 at any desired speed, by any suitable means about a horizontal axis (not shown).

11 is the film of thermoplastic material which passes in the direction of the arrow 12 from a let-off roller (not shown) to the hollow cylinder 7 for the flaming treatment, and from said cylinder, after treatment, in the direction of the arrow 13 to a take-up roller (not shown).

The material is in a slightly stretched condition when passing from the let-off to the take-up roller, and makes contact with a segment of the cylinder 7 of slightly less than 180°. The drive of the parts is such, however, that the cylinder 7 and the portion of the film in contact therewith, move as one and have no relative movement.

14 is a burner comprising a hollow chamber 15 connected by a pipe 16 to a mixing chamber 17 to which Town gas and air are supplied by the pipes 18 and 19 respectively. The burner has a channelled mouth 20, the

base of which has a horizontal row of spaced bores 21 opening to the hollow chamber 15 of the burner and forming outlets for the mixture of Town gas and air. When the burner 14 is lit, each of the bores 21 has a flame 22 projecting therefrom, and the burner 14 is so supported and adjusted that the flame projects horizontally so that its tip 23 just impinges on the outer surface of the plastic film 11 in about the mid-position of the segment of contact of the film with the cylinder 7, as shown in Figs. 1 and 2.

The edges of the base of the channelled mouth 20 have horizontal cuts 24 of desired width which open at the front into the mouth 20 and at the rear are just slightly spaced from the bounding wall of the chamber 15. However, at spaced positions within said chamber 15 there are bores 25, shown dotted in Fig. 4, which allow the gaseous mixture to pass to the cuts 24 and then to the mouth. This additional supply of gaseous mixture, when the burner is lit, tends to unify all the separate flames 22 into a single "blade-like" flat flame, with its outer edge contacting the outer surface of the film 11. To keep the cylinder 7 cool and prevent it overheating during the treatment of the film to produce the perforations, a liquid coolant such as water is caused to enter the cylinder by one hollow stub spindle 8, in the direction of the arrow 26, and leave it in the direction of the arrow 27 by the other hollow stub spindle.

Utilising an apparatus as shown diagrammatically in Figs. 1 to 4 of the drawings, in one experimental method of carrying the invention into effect a polyester film 0.00025" thick, known by the (R.T.M.) Registered Trade Mark "Melinex," was run with the rotating cylinder 7 engraved with indentations or cells of the somewhat flattened oval shape shown enlarged in Fig. 6. Each cell was of the following dimensions: 0.010" wide, 0.020" long, and 0.004/0.005" deep, and the cells were arranged in staggered rows both circumferentially and longitudinally at desired spacing. The temperature of the flame at the point of contact with the surface of the film was over 1200°C, and the linear speed of the film was approximately 10 yards per minute.

From this it will be seen that the actual flaming of any particular portion of the film to produce the perforations took place over a period of time represented by a very small fraction of one second, i.e., less than one-hundredth.

In the result, the treated longitudinally extending area of the film had a regular pattern of parallel rows of perforations therethrough which approximated closely to the shape and spacing of the engraved cells on the surface of the cylinder.

Obviously, with higher running speeds the flame temperature could be greater, for ex-

ample could have the normal temperature of gas flames, which is within the region of 1400°C to 1700°C.

Fig. 5 shows a greatly enlarged portion of Fig. 1 within the neighbourhood of where the tip 23 of the flame 22 impinges upon the film 11; this Fig. 5 also shows cells 28 in the surface of the cylinder 7.

As will be appreciated from the Figure, the metal of the cylinder 7 is cold, due to the liquid coolant, and similarly the air included in the cells 28 which are approaching the flame, is cold and at the same temperature as the metal of the cylinder. The lower portion of Fig. 5 shows the film 11 moving towards the flame 22 and this film covers in the cells 28 and imprisons the cold air therein. When the film portion which has the metal of the cylinder behind it reaches the tip 23 of the flame, the heat of the flame passing through the material of the film 11 is immediately conducted away by the cold metal and the amount of heat supplied in the short time period is insufficient to melt the film and consequently the part of the film supported by the metal of the cylinder passes by the flame without becoming melted.

However, when a portion of the film which is backed by the air pocket of a cell, and which is cooled to the same temperature as the portion of the film with the metal of the cylinder behind it, as the air in the pocket is cold and at the same temperature as said metal, reaches the tip 23 of the flame 22, the heat conductivity of the air in the pocket is much less than that of the metal and as a consequence the heat cannot escape so rapidly from the film backed by the air pocket, even in the short time period and is sufficient to melt the film in these air pocket positions, to form the perforations. The expansion of the air held in the pocket, by the heat, also contributes to the perforating action. In Fig. 5 it will be seen how the cell 28 just above the tip of the flame has a perforation 29 at its open face, whilst the portion of the film 11 just above this perforation 29, although it has previously passed through the flame 22, has not been melted.

Fig. 6 shows to a highly enlarged scale, a portion of a perforated film 30 which has been made according to the invention. Here, the perforations 31 are of a somewhat elongated oval shape having dimensions approximating to those of the cells just particularly given. The width of the unperforated film between the vertical rows of perforations and the horizontal rows of perforations, is 0.030".

Another practical apparatus could comprise an endless band of thin steel or other metal, the outer surface of which has the indentations. This band passes through an

endless path over one or more guide and tensioning rollers, and in one position passes around a portion of a hollow cylinder of metal or other suitable material.

5 In turn, the film to be perforated is placed under slight tension and passes to a part of the endless band which is on the cylinder.

10 In operation, the film, endless band and hollow metal cylinder move as one over that portion of the films path in which the film contacts the indented surface of the metal band, and in an intermediate position of this portion the flaming treatment, such as hereinbefore described, is applied.

15 The pattern of indentations on the curved metal surface, or the metal band, may be produced in any suitable manner according to the nature of the pattern. In most cases, for an efficient and non-costly production, the indentations may be etched in accordance with any known etching process suitable for the purpose. Thus there will be no difficulty in producing a pattern of closely spaced small shallow etched indentations suitable for the continuous production of uniformly perforated films having approximately a thousand or more perforations per square inch such as hereinbefore set forth.

25 The invention is not limited to the precise forms or details herein described, as these may be varied to suit particular requirements.

WHAT WE CLAIM IS:—

35 1. A method for imparting to a film of any suitable thermoplastic material which is capable of being softened and melted by heat, a pattern of perforations which may be fine perforations and which extend through the thickness of the film, which thickness is within the range of approximately 0.00025" to 0.005", comprising holding the film slightly stretched over and in contact with a segment of a cylindrically curved metal surface, said curved surface 45 having a pattern of air-containing indentations thereon of very slight depth, which may range from a few thousandths of an inch upwards, and whilst so held and without moving the film in relation to the curved metal surface, subjecting the outer surface of the thus held thin film to the heat at the tip of a flame which has a temperature of 1200°C or more and is directed onto the surface of the film for only a small fraction 50 of a second, which is insufficient to melt the material of the film where it is in contact with the metal owing to the high heat conductivity of the metal, but long enough to melt the said material where it is located over the indentations, owing to the relatively 55 low heat conductivity of the air in the indentations, and the expansion of the air held in the indentations, by the heat, the flame heating action being effected by moving the said flame or simultaneously moving a

plurality of said flames in relation to the outer surface of the film so that all parts of the whole area to be perforated are subjected to the very short period of treatment, to produce a pattern of perforations through the material which corresponds to that of the indentations on the metal surface.

2. A method for imparting to a film of any suitable thermoplastic material which is capable of being softened and melted by heat, a pattern of perforations which may be fine perforations and which extend through the thickness of the film, as claimed in claim 1, in which the curved metal surface with the pattern of indentations thereon is that of a hollow metal cylinder rotating on a horizontal axis, with which the film under slight tension is held in contact with a desired segment of said surface, the film proceeding from a let-off roller to a take-up roller at a desired linear speed, for example ten yards per minute, in such manner that the portion of the film in contact with the hollow cylinder moves with the indented curved surface thereof, to pass the outer surface of the film for treatment in front of a row of horizontal flames from a single burner for a combustible gaseous mixture, a liquid coolant such as water passing into and out of the hollow cylinder to keep the metal having the indented outer surface and the air held in the indentations up to the flaming position at the same required low temperature.

3. A method for imparting to a film of any suitable thermoplastic material which is capable of being softened and melted by heat, a pattern of perforations which may be fine perforations and which extend through the thickness of the film, as claimed in claims 1 and 2, modified in that the rotatable metal cylinder co-operates with an endless band of thin steel or other metal, the outer surface of which band has the indentations and which band passes through an endless path over one or more guide and tensioning rollers and in one position passes around a portion of the said rotatable metal cylinder, the film to be perforated, which is under slight tension, passing to a part of the endless band which is on the cylinder and moving with this part of the band, in such manner that the film, endless band and hollow metal cylinder move as one over that portion of the films path in which the film contacts the indented surface of the metal band, the flame heating being applied in an intermediate position of this portion.

4. Perforated films of thermoplastic material which is capable of being softened and melted by heat, when made by the method of claim 1 or claim 2 or claim 3.

5. A method for imparting to a film of any suitable thermoplastic material which is capable of being softened and melted by

heat, a pattern of perforations which may be fine perforations and which extend through the thickness of the film, substantially as herein set forth with reference to the accompanying drawings.

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